IMPACT OF VARIABLE TRANSMISSION RANGE ON MANET PERFORMANCE

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ABSTRACT

Mobile Ad-hoc Network (MANET) is generally established in areas where infrastructural facilities such as base station, routers etc. do not exist or have been destroyed due to natural calamity. Due to their infrastructure-less nature they have several constrains such as bandwidth, computational capacity and battery power of each node. Power conservation is crucial to proper operations of MANET. Various researchers have provided several mechanisms to reduce the power consumption. One such mechanism is to take variable transmission range of nodes into account. This paper studies the impact of the same by designing a simulator in MATLAB. We observe a marked impact of variable transmission range on power saving.

KEYWORDS

Ad hoc Networks, MANET, Network Protocols, Power Saving.

1. INTRODUCTION

MANETs [1] consists of mobile nodes that communicate with each other through either direct link or multi-hop wireless links in the absence of fixed infrastructure. It is an infrastructure less network because it does not require any fixed infrastructure support such as a base station for its operation. The network is fully decentralized in the sense that all the network activity likes discovering of path; message processing or message passing must be done by nodes themselves using certain routing protocols [2, 3, 4].

Each node in MANET utilises its limited residual battery power for its network operations. There are some basic problems related to battery power like difficulties in replacing the batteries in the field, recharging of the batteries, selection of optimal transmission power etc. Due to all these problems power management [5, 6, 7] is an important issue in MANET. Efficient utilization of battery power increases the network lifetime hence is critical in enhancing the network capacity [8, 9]. To increase the network lifetime, a routing protocol should contain the following metrics [10]:

- **Minimal energy consumption per packet:** This metric tries to minimize the power consumed by a packet in traversing from source to destination node. As the energy consumed is a function of distance hence the routing protocol chooses a path with large hop count 11].
- **Maximize network connectivity:** This metrics tries to balance the routing load among the nodes of network. In this way the network life time is prolonged [12].
- **Minimum variance in node power level:** This metric tries to balance the load among the cut-set (the subset of the nodes in the network, the removal of which results in network partitions). This is important in scenarios where network connectivity is to be ensured [13].
- **Minimum cost per packet:** A node cost decreases with increase in its battery charge and vice versa. Translation of the remaining battery charge to a cost factor is used for routing. With the availability of a battery discharge pattern, the cost of a node and at the same time congestion handling is done [14].
- **Minimize maximum node cost:** This metric tries to minimize the maximum cost per node for a packet after routing a packet or after a specific period. It in turns helps in delaying the node failure chances in near by future therefore also helps in increasing the network lifetime.

In this paper we employed variable transmission range of nodes and tried to find its impact on the performance of routing protocols. To evaluate the performance of routing protocols the following performance metrics were taken into considerations:

- **Energy Consumption:** Defined as the total energy consumed for a packet in traversing from source to destination.
- **Percentage Power Saving (PPS):** Defined as the ratio of the total transmission power saved using variable transmission range to power consumed using fixed transmission range. It is calculated using the equation as follows:

$$PPS = (100 \text{ X } (E_f - E_v))/E_f$$

Where E_f denotes the fixed transmission energy loss

E_v denotes the variable transmission energy loss

The rest of the paper is organized as follows: In the next section we give some preliminaries about the energy model and the assumptions made related to our work. Section 3 gives some basic energy efficient routing protocols. Section 4 gives the simulation and results. We finally conclude in the section 5.

2. PRELIMINARIES

During the route search process the neighbours transmit the route request packets using maximum value of transmission range of a node. The nodes note down the received signal strength (RSSI) during route search phase and adjust their transmission power level and transmission range during the data transmission phase in such a manner that the neighbours receive the packet with enough energy. Here it is assumed that the link is having same characteristics in both the directions and the packets are of same size (number of bits). To calculate of energy loss at a node, the following energy model equations are used. The amount of energy required for transmission (E_t) of a fixed size packet is given by the equation.

$$E_t = r^{\alpha} + C_e \qquad (1)$$

r is transmission range of a node

α is constant
C_e = Constant energy dissipated in transmitter circuitry
E_t is energy consumption at transmitter side

The value of $\alpha = 4$ and the $C_e = 10^8$ is derived from Rodoplu and Meng [15]. These values are taken in arbitrary units and can be converted into any given units by using a multiplication factor.

The nodes consume some constant energy (E_r) upon reception also which is independent of the distance between the participating nodes. The value of E_r can be calculated by the equation as under:

$$E_r = C_r \qquad (2)$$

C_r = Constant energy consumed in reception
E_r is the energy consumption at receiver side

In our case the reception energy [16] taken is $C_r = (2/3) \text{ X } 10^8$. Thus the total amount of energy consumed (E) by a relay node is given as under:

$$E = E_t + E_r \qquad (3)$$

Using equations (1) and (2) we can rewrite the (3) equation as under:

$$E = r^{\alpha} + C_e + C_r.$$

3. RELATED WORK

Energy efficiency continues to be a key performance metric as efficient utilization of energy increases the network lifetime and capacity. So efforts are made to reduce the energy consumption in different ways. To utilise the residual battery power of nodes in an effiecient manner, researchers have taken variable transmission range [16-20] of nodes into accounts as follows:

Fatiha Djemili Tolba et. al. [17] Proposed a new approach to control the energy used in ad hoc network based on variable transmission range. The transmission range is varied according to the position of the node, if the node has no neighbours then it takes the maximum value of the transmission range and if the node has sufficient number of nodes then it takes the distance as a transmission range. The result shows that network capacity improves a lot when variable transmission range is employed.

Ingelrest et. al. [16] investigates the problem of minimum energy broadcasting in ad hoc network. Two localized broadcasting protocols were presented based on derived "target" radius, these are (i) The target radius local minimum spanning tree(LMST) broadcasting oriented protocol(TR-LBOP). It finds the minimal radius for connectivity and to increase it up to the target one. On this basis the transmission range is computed thus energy consumption is minimised (ii) The target radius and dominating sets-based (TRDS) protocol gives a unique solution to two different problem minimum energy broadcasting and activity scheduling.

Arwa Zabian et. al. [18] proposed a graph search algorithm. They used variable transmission range to prolong the lifetime of a node and save it from becoming dead. Their simulation results have confirmed the same.

Donia Bein et. al. [19] proposed three distributed algorithms for self-adjusting the transmission range of nodes in a wireless sensor network. The main objective is to vary the transmission range in such way that it gives lower energy consumption for sending a packet from source to destination.

Jang-Ping Shev et. al. [20] proposed a distributed transmission power control algorithm which prolong the life time of sensor node by saving the energy consumption and enhance the performance of packet delivery ratio. This algorithm has two phases (i) Initial phase which finds an initial transmission power for each neighbouring nodes (ii) maintaining phase which determines and adjusts the proper transmission power level with the environmental changes. Each sensor node uses RSSI (received signal strength indicator) and LQI (link quality indicator) value to determine the proper transmission power level that can achieve high packet delivery ratio and save transmission energy.

3. SIMULATIONS AND RESULTS

A simulator was designed in MATLAB in which an area of 900 sq. unit's size was chosen. The nodes were randomly distributed using the *randint()* function used in MATLAB. Two routing strategies named as Minimum Hop Routing (MHR) and Minimum Total Power Routing (MTPR) was implemented using Dijkstra's shortest path algorithm. Figure 2(a) and (b) shows the paths created by the two routing mechanisms. The red line in the figures shows the path created by using MTPR and MHR routing algorithms. To measure the impact of variable transmission range on the network performance, the energy consumed for a route is calculated by taking fixed and variable transmission range of nodes. The flowchart given in Fig.1 shows the same as discussed above.

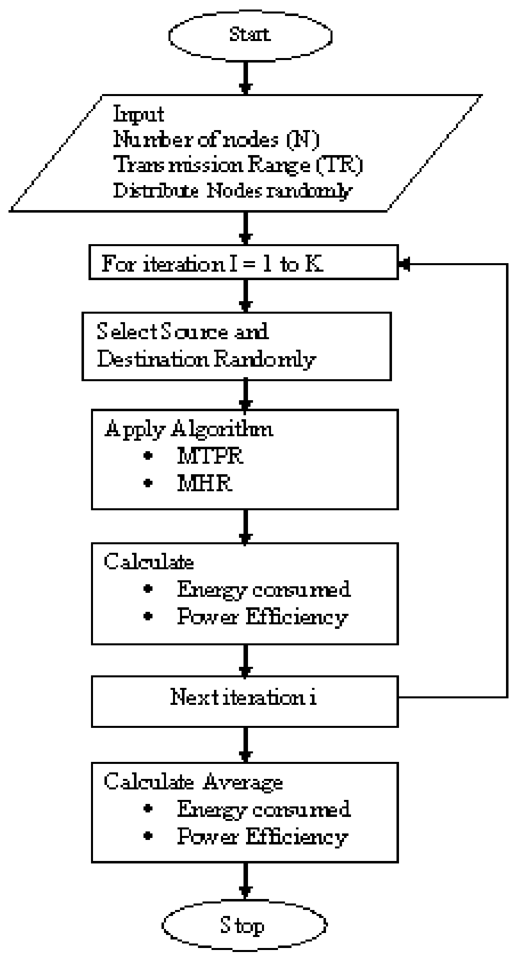

Figure 1. Flow chart of the simulator

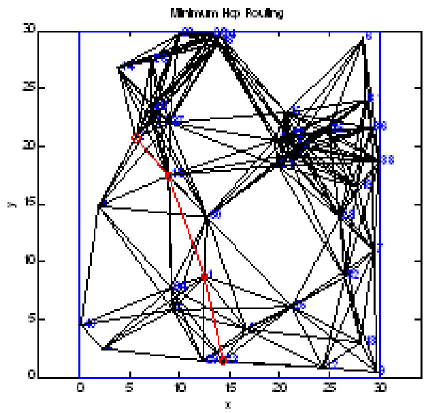

Figure 2(a) Minimum Hop routing

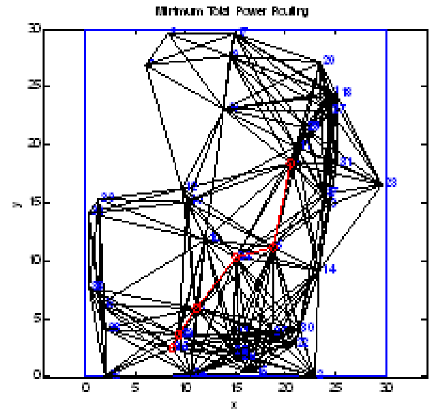

Figure 2(b) Minimum Total Power Routing

4.1. Simulation Set up Parameters

Table 1 provides the simulation parameters as follows:

Table 1: Simulation set up parameters

Routing Protocol used	Minimum Hop Routing(MHR) Minimum Total Power Routing(MTPR)
Transmission Range	Variable(Based on Received Signal Strength Indicator(RSSI))
Number of nodes deployed	30,35,40,45and 50
Simulation Area	900 sq units (Square Area)
Nodes Placement Strategy	Random
Number of iteration	25

4.2. Impact on Power Consumption

Figure 3 shows average power consumption on both the routing strategies. It shows that MHR consume higher power as compared to the MTPR. The result also shows that as the number of nodes increases, power consumption increases in both the routing mechanisms but is more prominent in MHR.

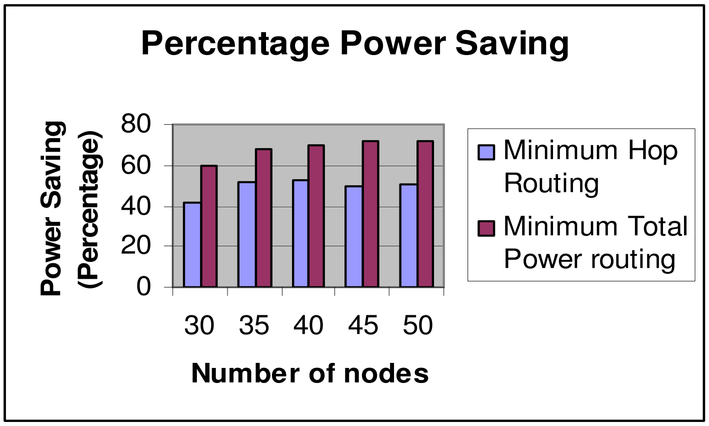

Figure 3. Impact of Variable Transmission Range on the Power Consumption

4.3. Impact on Percentage Power Saving (PPS)

Figure 4 shows the impact of variable transmission range on PPS on both the Routing strategies. The graph shows that Power efficiency of MTPR is higher than MHR; it means MTPR saves much more energy than in case of MHR. It can be easily seen from the figure that MTPR saves nearly 60% energy where as it is at least 40% in case of MHR.

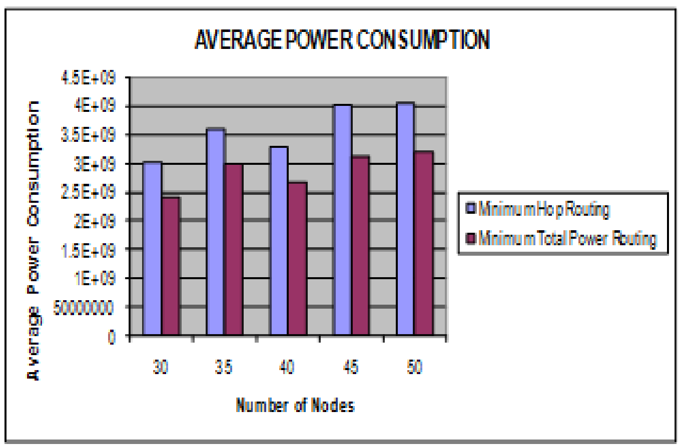

Figure 4. Impact of Variable Transmission Range on PPS

5. CONCLUSION

This paper investigated the impact of variable transmission range on power saving in MANETs. The performance analysis was done on two routing protocols: Minimum Hop Routing (MHR) and Minimum Total Power Routing (MTPR). After analyzing the results of our work, we make following inference:

- Power saving of MTPR is always higher than MHR It indicates to increase the percentage power saving MTPR protocol should be used rather then MHR.
- Power consumption of MHR is higher than MTPR because MHR takes a path that tries to minimize number of nodes to reach to destination. On the other hand MTPR tries to select a path that tries to minimize the total power from source to destination.

Above analysis shows that variable transmission range has the potential to increase the power savings of mobile ad hoc networks and hence the network lifetime.

This paper presents a strong reason for the use of variable transmission range in future mobile ad hoc network and we believe variable transmission range is more suitable to the needs of mobile ad hoc network, their devices and applications. In short, variable transmission range is keystone the design of future mobile ad hoc network.

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